

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/SE2004/001701

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of: Cover sheet

INTERNATIONAL PATENT CLASSIFICATION (IPC):

H01L 21/027 (2006.01)

G02B 26/00 (2006.01)

G03F 7/20 (2006.01)

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Box No. I Basis of the report

1. With regard to the language, this report is based on:

- ☐ the international application in the language in which it was filed
- ☐ a translation of the international application into _____
which is the language of a translation furnished for the purposes of:
- ☐ international search (Rules 12.3(a) and 23.1(b))
- ☐ publication of the international application (Rule 12.4(a))
- ☐ international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the elements of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

- ☐ the international application as originally filed/furnished
- ☒ the description:
pages 1-10 as originally filed/furnished
pages* _____ received by this Authority on _____
pages* _____ received by this Authority on _____
- ☒ the claims:
pages _____ as originally filed/furnished
pages* 11-16 as amended (together with any statement) under Article 19
pages* _____ received by this Authority on _____
pages* _____ received by this Authority on _____
- ☒ the drawings:
pages 1-5 as originally filed/furnished
pages* _____ received by this Authority on _____
pages* _____ received by this Authority on _____
- ☐ a sequence listing and/or any related table(s) – see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets/figs _____
- ☐ the sequence listing (*specify*): _____
- ☐ any table(s) related to the sequence listing (*specify*): _____

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets/figs _____
- ☐ the sequence listing (*specify*): _____
- ☐ any table(s) related to the sequence listing (*specify*): _____

* If item 4 applies, some or all of those sheets may be marked "superseded."

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Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application

☒ claims Nos. 2, 25

because:

☐ the said international application, or the said claims Nos. _____
relate to the following subject matter which does not require an international preliminary examination (*specify*):

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 2, 25
are so unclear that no meaningful opinion could be formed (*specify*):

Claims 2 and 25 are considered to be statements of desiderata as they lack all technical features necessary for achieving the alleged non-uniformity.

☐ the claims, or said claims Nos. _____ are so inadequately supported by the description that no meaningful opinion could be formed (*specify*):

☒ no international search report has been established for said claims Nos. 2, 25

☐ a meaningful opinion could not be formed without the sequence listing; the applicant did not, within the prescribed time limit:

☐ furnish a sequence listing on paper complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Preliminary Examining Authority in a form and manner acceptable to it.

☐ furnish a sequence listing in electronic form complying with the standard provided for in Annex C of the Administrative Instructions, and such listing was not available to the International Preliminary Examining Authority in a form and manner acceptable to it.

☐ pay the required late furnishing fee for the furnishing of a sequence listing in response to an invitation under Rules 13ter.1(a) or (b) and 13ter.2.

☐ a meaningful opinion could not be formed without the tables related to the sequence listings; the applicant did not, within the prescribed time limit, furnish such tables in electronic form complying with the technical requirements provided for in Annex C-bis of the Administrative Instructions, and such tables were not available to the International Preliminary Examining Authority in a form and manner acceptable to it.

☐ the tables related to the nucleotide and/or amino acid sequence listing, if in electronic form only, do not comply with the technical requirements provided for in the Annex C-bis of the Administrative Instructions.

☐ See Supplemental Box for further details.

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Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	<u>1, 3-24 and 26</u>	YES
	Claims	_____	NO
Inventive step (IS)	Claims	<u>1, 3-24 and 26</u>	YES
	Claims	_____	NO
Industrial applicability (IA)	Claims	<u>1, 3-24 and 26</u>	YES
	Claims	_____	NO

2. Citations and explanations (Rule 70.7)

The application refers to a method and an apparatus to pattern a work piece where the improved CD uniformity is a function of the number of exposure flashes from the partially coherent electromagnetic radiation source.

Reference is made to the following documents:

D1: US 4970546 A1
D2: JP 2135723, abstracts of Japan
D3: JP 3179357, abstracts of Japan
D4: US 4822975 A1

Document D1 concerns an illumination control device which uses a minimum number of pulses required for substantially smoothing a speckle pattern. See for example the abstract, column 2, lines 47-52 or column 3, lines 1-10.

Document D2 is related to an exposure controlling device controlling the quantity of exposure and adjusting the quantity of light. See abstract.

Document D3 describes an exposure controller which optimizes the quantity of exposure and uniformizes the illuminance. See abstract.

Document D4 concerns a method and apparatus for scanning exposure with a pulsed laser beam. It describes a relationship between the number of pulses and the distance between two positions in the scan direction corresponding to the intensity level portions. See especially the abstract and column 4,

.../...

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of: BOX V

lines 3-36.

The method and apparatus for patterning a work piece by determining the uniformity as a function of the number of flashes described in document D1 are considered as representing the most relevant prior art. The invention as defined in claims 1-4 differs from this technique in that it uses a partially coherent electromagnetic radiation source having a speckle pattern which is a fine grained random variation in illumination different from mode to mode and/or flash to flash, and in that the uniformity is determined for a plurality of layers.

The invention as defined in the independent claims 5-8 and 18-22 differs from the technique described in D1 in that it uses a partially coherent electromagnetic radiation source having a speckle pattern which is a fine grained random variation in illumination different from mode to mode and/or flash to flash, and in that the uniformity is improved by changing different parameters, such as the number of exposure flashes or the radiation band width.

The invention as defined in the independent claim 10 differs from the technique described in D1 in that it uses a partially coherent electromagnetic radiation source having a speckle pattern which is a fine grained random variation in illumination different from mode to mode and/or flash to flash, and in that the uniformity is improved by increasing different parameters, such as the number of exposure flashes or the radiation band width.

The invention as defined in the independent claim 24 differs from the technique described in D1 in that it uses a partially coherent electromagnetic radiation source having a speckle pattern which is a fine grained random variation in illumination different from mode to mode and/or flash to flash, and in that it optimizes a speckle during microlithographic printing.

However, none of the above mentioned documents, D1-D4, includes a partially coherent radiation source giving rise to a random speckle pattern. Therefore, what is mentioned in

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of: BOX V

claims 1, 4-8, 10, 18-22 and 24 is considered new and including an inventive step.

Also what is mentioned claims 3, 9, 11-17 and 26 is considered new and involving an inventive step.

The technique described in claims 1-26 is industrially applicable.
lines 3-36.

The method and apparatus for patterning a work piece by determining the uniformity as a function of the number of flashes described in document D1 are considered as representing the most relevant prior art. The invention as defined in claims 1, 4-8, 10, 18 and 23-25 differs from this technique in that it uses a partially coherent electromagnetic radiation source having a speckle pattern which is a fine grained random variation in illumination different from mode to mode and/or flash to flash.

However, none of the above mentioned documents, D1-D4, includes a partially coherent radiation source giving rise to a random speckle pattern. Therefore, what is mentioned in claims 1, 4-8, 10, 18 and 23-25 is considered new and including an inventive step.

Also what is mentioned claims 2-3, 9, 11-17, 19-22 and 26 is considered new and involving an inventive step.

The technique described in claims 1-26 is industrially applicable.

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Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

Claims 2, 3, 10-13, 18-21, 23, and 25-26 (in part) are considered to be statements of desiderata as they lack all technical features necessary for achieving the alleged non-uniformity. Consequently, the search is directed only towards the technical features mentioned.

All abbreviations should be written out in full, so as to clarify what they stand for. For example CD, NA, MEEF factor etc.

In [0039] it should read "Instead of a reticle it has..." and in [0048] the word micromirror should have two "r".

17-05-2005

AP20 Rec'd PCT/PTO 16 MAY 2006

CLAIMS

- 1 1. A method to pattern a workpiece with improved CD uniformity using a
2 partially coherent electromagnetic radiation source having a speckle
3 pattern which is a fine grained random variation in illumination
4 different from mode to mode and/or flash to flash, including the
5 actions of:
- 6 - determining, for a plurality of layers in said workpiece, CD
7 uniformity due to said speckle as a function of a number of
8 exposure flashes,
 - 9 - determining, for a plurality of layers in said workpiece, the
10 cost of patterning as a function of the number of exposure
11 flashes,
 - 12 - selecting the number of exposure flashes on a layer by layer
13 basis, which gives a predetermined CD uniformity
14 corresponding to a preferred cost.
- 1 2. The method according to claim 1, further comprising the action of:
- 2 - selecting a combination of values of the following
3 parameters:
- 4 • radiation bandwidth
 - 5 • pulse length
 - 6 • radiation flash frequency
- 7 so that a calculated illumination non-uniformity (3 sigma) from
8 speckle amounts to less than 0.5%.
- 1 3. The method according to claim 1 or 2, further comprising the action of:

- 2 - determining a value of a slit width so that a calculated
3 illumination non-uniformity (3 sigma) from speckle amounts
4 to less than 0.5%.
- 1 4. A computer assisted apparatus for printing a workpiece with improved
2 CD uniformity by using a partially coherent radiation source having a
3 speckle pattern which is a fine grained random variation in
4 illumination different from mode to mode and/or flash to flash,
5 comprising:
6 - logic and resources that determine, for a plurality of layers in
7 said workpiece, CD uniformity due to said speckle as a
8 function of the number of exposure flashes,
9 - logic and resources that determine, for the plurality of layers
10 in said workpiece, a cost of patterning as a function of the
11 number of exposure flashes,
12 - logic and resources that select the number of exposure flashes
13 on a layer by layer basis, which gives a predetermined CD
14 uniformity at a minimum of patterning cost.
- 1 5. A method for printing a workpiece with improved CD-uniformity by
2 using a partially coherent radiation source having a speckle pattern
3 which is a fine grained random variation in illumination different from
4 mode to mode and/or flash to flash, including the action of:
5 - changing a number of exposure flashes per surface element
6 on a layer by layer basis.
- 1 6. A method for printing a workpiece with improved CD-uniformity by
2 using a partially coherent radiation source having a speckle pattern

3 which is a fine grained random variation in illumination different from
4 mode to mode and/or flash to flash, including the action of:

- 5 - changing a pulse length of exposure flashes per surface
6 element on a layer by layer basis.

1 7. A method for printing a workpiece with improved CD-uniformity by
2 using a partially coherent radiation source having a speckle pattern
3 which is a fine grained random variation in illumination different from
4 mode to mode and/or flash to flash, including the action of:

- 5 - changing a radiation bandwidth of exposure flashes per
6 surface element on a layer by layer basis.

1 8. A method for printing a workpiece with improved CD-uniformity by
2 using a partially coherent radiation source having a speckle pattern
3 which is a fine grained random variation in illumination different from
4 mode to mode and/or flash to flash, including the action of:

- 5 - changing a slit width of exposure flashes per surface element
6 on a layer by layer basis.

1 9. The method according to any one of claims 5-8, wherein said changing
2 is performed for critical layers in the microelectronic device only.

1 10. A procedure to improve CD uniformity of a layer exposed in a scanner
2 or stepper using partially coherent light having a speckle pattern, which
3 speckle pattern is a fine grained random variation in illumination different
4 from mode to mode and/or flash to flash, including the actions of:

- 5 - providing a scanner system with an optical field larger than 10 mm,
6 - increasing one or more of the following parameters

7 a. slit width,

- 8 b. laser bandwidth,
9 c. pulse length,
10 d. laser flash frequency,
11 e. number of flashes,
12 f. number of flashes per field,
13 g. number of scan cycles per field
14 until the calculated illumination non-uniformity (3 sigma) from said speckle
15 amounts to less than 0.5%.

- 1 11. The procedure as in claim 10 but with calculated speckle less than 1%.
1 12. The procedure as in claim 10 but with calculated speckle less than 2%.
1 13. The procedure as claimed in claim 10 but with calculated speckle less than
2 3%.
1 14. The procedure according to claim 10, wherein non-polarised light is used.
1 15. The procedure according to claim 10, wherein refractive optics is used.
1 16. The procedure according to claim 15, wherein at least one diffractive
2 element is used.
1 17. The procedure according to claim 15, wherein catadioptric optics with at
2 least one diffractive element is used.
1 18. A procedure to improve CD uniformity of a layer exposed in a maskless
2 scanner using partially coherent light having a speckle pattern which is a fine grained
3 random variation in illumination different from mode to mode and/or flash to flash
4 comprising the steps of:

- 5 - providing a maskless scanner systems with an optical field larger than
6 0.5mm,

7 - increasing one or more of the following parameters:

8 a. laser bandwidth,

9 b. pulse length,

10 c. number of overlayed flashes,

11 until the calculated illumination non-uniformity (3 sigma) from said
12 speckle amounts to less than 0.5%.

1 19. The procedure according to claim 18, wherein said calculated speckle is less
2 than 1%.

1 20. The procedure according to claim 18, wherein said calculated speckle is less
2 than 2%.

1 21. The procedure according to claim 18, wherein said calculated speckle is less
2 than 3%.

1 22. The procedure according to claim 18, wherein non polarized light is used.

1 23. An apparatus for printing a workpiece with improved CD uniformity
2 including:

3 - logic and resources to calculate speckle, which speckle is a fine grained
4 random variation in illumination different from mode to mode and/or flash to
5 flash,

6 - logic and resources that change the number of pulses per surface element on
7 a layer to layer basis.

1 24. A procedure for optimizing speckle, which is a fine grained random variation
2 in illumination different from mode to mode and/or flash to flash, during
3 microlithographic printing including the actions of:

4 - providing a model for the value of improved CD uniformity,

5 - calculating the CD uniformity as a function of the number of flashes,

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- 6 - providing a model for the cost of printing with a particular number of
7 pulses,
8 - providing logic and resources that select a number of flashes that
9 corresponds to a preferred result,
10 - providing a control adapted to change the number of flashes, and
11 - setting said approximately optimized number of flashes.

1 25. An electronic device with improved CD uniformity printed with speckle,
2 which speckle is amounting from fine grained random variation in illumination
3 different from mode to mode and/or flash to flash, less than 1% (3 sigma).

1 26. The method according to claim 23, further including the actions of:

- 2 - determining, for a plurality of layers in said workpiece, CD uniformity as a
3 function of a number of exposure flashes,
4 - determining, for the plurality of layers in said workpiece, the cost of
5 patterning as a function of the number of exposure flashes,
6 - selecting the number of exposure flashes on a layer by layer basis, which
7 gives a predetermined CD uniformity corresponding to a preferred cost.

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